Autonomous Functionalization of Natural Fibers for Advanced Materials

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Objectives: Develop an autonomous high-throughput experimental approach to the exploration of functionalization chemistry for natural fibers. This will be applied to cellulose nanocrystals or nanofibers in support of GT efforts with these materials. Demonstration that an optimal functionalization chemistry for compatibilizing cellulosic fibers with polymer composites would be a significant and potentially disruptive advance.

Technical Approach:
Challenges to be addressed include (1) dispersal of cellulosic fibers in reaction medium by using miniaturized and robotic dispensing tools, (2) exploration of new and orthogonal functionalization chemistries, particularly those that do not require high-boiling, polar organic solvents like DMSO, (3) characterization of functionalization products including their colloidal stability and surface coverage through high-throughput screening tools. We envision utilization of a commercial platform, e.g. the Chemspeed ISYNTH station that will be coupled with automated spectroscopic tools. The latter will be a subject of innovation in this project as well, and would include use of multisolvent suspension or emulsion stability to quickly screen particle functionalization.
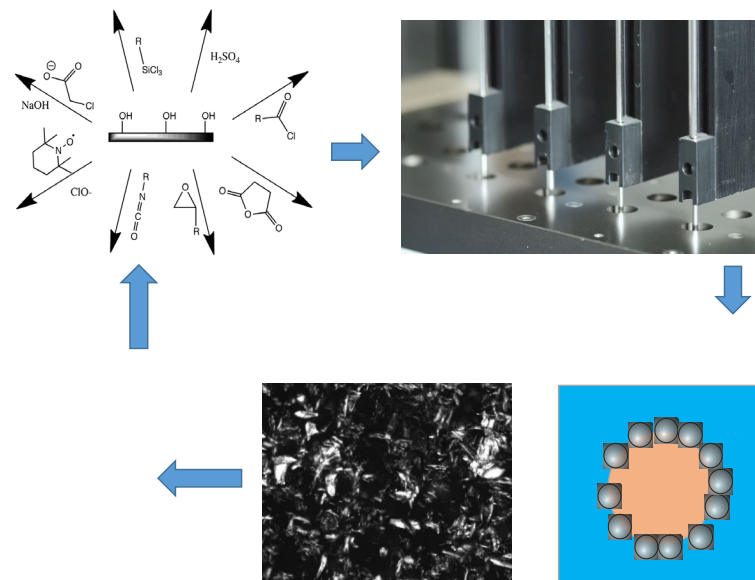
Impact: There are relatively few approaches for functionalizing cellulose nanofibers for compatibility with polymer matrices. The field is bottlenecked by traditional low throughput approaches coupled with the challenges of dispersing these fibers in solvent in which functionalization chemistry is compatible. High-throughput development tools have rarely been applied to natural, renewable materials problems. A successful HT approach could disrupt technology development, allowing rapid breakthroughs in greener and lower-cost chemistry for cellulose modification, and enabling the utilization of these fibers in wider ranges of materials applications.